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## Analysis of the Configuration and Motion of Coal Particles in Fluid Bed

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# Analysis of the Configuration and Motion of Coal Particles in Fluid Bed

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**Abstract.** The fineness of pulverized coal has significant influence on the combustion pollutant, the image recognition method is directly aimed at the size and shape information of pulverized coal particles, which eliminates the possible errors in the transformation process and makes the measurement results accurately reflect the particle information. In this paper, the image recognition method is used to measure and collect the particle shape and fineness information of pulverized coal. By combining the Discrete Element Method (DEM) with the Computational Fluid Dynamics (CFD), the vibration flow behavior and movement regularity of lignite was simulated in vertical fluidized beds. The result shows that the difference of shape factor between micron-level coal particles and millimeter-scale coal particles is not very large.

## 1. Introduction

The fineness of pulverized coal has a great influence on the safety of boilers' combustion. Firstly, the increase of coal fineness will delay the ignition time, cause the flame center' move up, easy to coking of the furnace. The main steam pipeline and reheat steam pipeline will cause over-temperature even Tube Explosion. Secondly, the increase of coal fineness will cause the decrease of burning rate, the increase of Amount of Carbon in Ash and the kinetic energy of the fly ash particles. The erosion of the pipes of the heating surface in the flue will be increased. The coal fineness will also influence the high temperature corrosion. The increase of the size of coal particles will cause the flame drag long, particles burn out difficult, water wall surface will be scoured and corroded by a large number of particles. In addition, the coarse coal particles can also cause boiler efficiency droop, furnace ignition temperature rise. [1, 2].

In the process of pulverized coal pneumatic conveying, the flow conditions, parameters and patterns are complex. The coal fineness is one of the most important parameters in combustion control and optimization [3]. The coal fineness directly influence the incomplete combustion heat loss, boiler combustion efficiency and the energy consumption of pulverizer [4]. In addition, different coal fineness will change the erosion wear position of the first duct.

In the past most calculation and simulation of pulverized coal flow have treated the shape of small size coal particles as spherical, the traction between the pulverized coal and the fluid can be modified by introducing shape factors, but if the shape is neglected, the collision between particles and the wall



of the container will cause greater error. Therefore, it is of great significance to measure and obtain the real shape of pulverized coal in gas-solid two-phase flow simulation [5].

## 2. Fineness and shape collecting of coal.

### 2.1. Information Collection of particle fineness

This paper chooses the fluidized bed coal particles from in Baoding thermal power plant as the coarse particles research object. Using vibrating screen machine and standard sieve to measure the fineness distribution particles. Choose 10 meshes, 18 meshes, 40 meshes, 75 meshes, 170 meshes, 300 meshes standard sieve to screen and separate particles, the representative 3 sets of results are shown in table 1.

**Table 1.** Sieving results of coarse pulverized coal particles

| Mesh Number | Particle size | Particle weight<br>(1)/g | Particle weight<br>(2)/g | Particle weight<br>(3)/g | Average mass<br>ratio % |
|-------------|---------------|--------------------------|--------------------------|--------------------------|-------------------------|
| 10 meshes   | >2mm          | 7                        | 6.6                      | 7.9                      | 13.43%                  |
| 18 meshes   | 1mm-2mm       | 10.7                     | 13.1                     | 11.1                     | 22.68%                  |
| 40 meshes   | 0.45mm-1mm    | 13.3                     | 16                       | 13.35                    | 29.46%                  |
| 75 meshes   | 0.2mm-0.45mm  | 7.1                      | 8.7                      | 6.5                      | 15.93%                  |
| 170 meshes  | 0.09mm-0.2mm  | 6.3                      | 7.5                      | 7.4                      | 14.00%                  |
| 300 meshes  | 0.05-0.09mm   | 0.85                     | 1.25                     | 1.1                      | 2.24%                   |
| bedplate    | 0.05mm-       | 0.55                     | 0.85                     | 0.65                     | 1.47%                   |

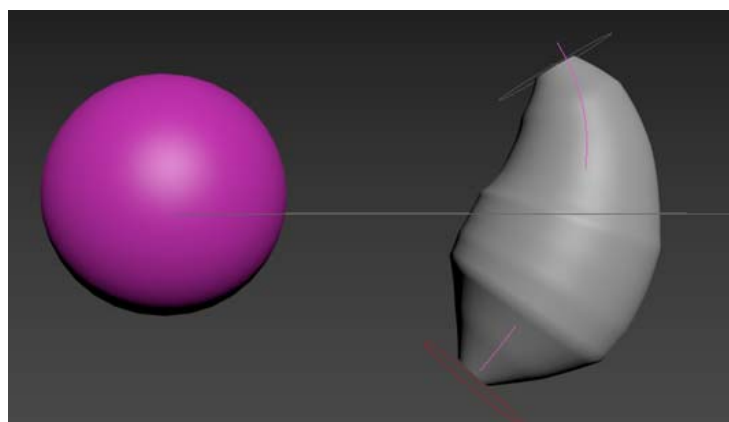
### 2.2. Calculation of the particles shape factor

In the simulation of gas-solid two-phase flow, CFD software is responsible for calculating the interaction between the particles and the fluid which is the main part of the drag force, in the calculation of drag, the CFD software to the particle as a sphere, and in the calculation formula to introduce the shape factor, so the calculation of shape factor is also an important part of the extraction of particle shape.

The formula of shape factor is

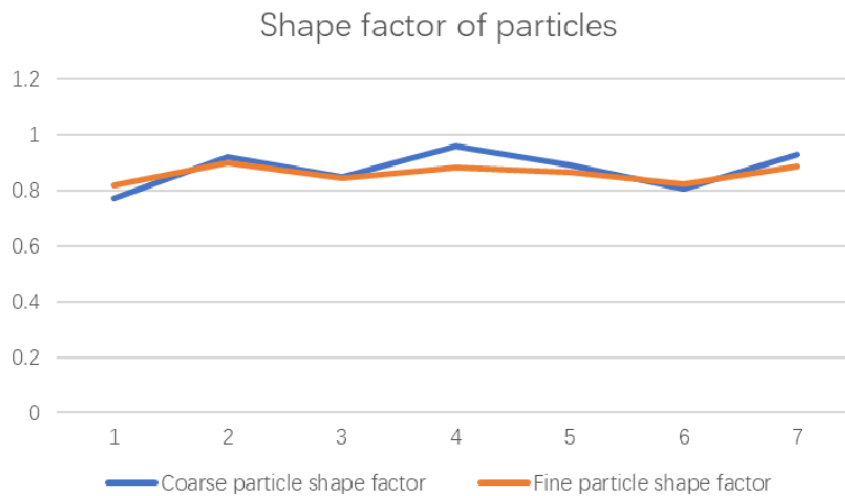
$$V=s1/s2 \quad (1)$$

In the formula, the s1 represents the surface area of the same volume sphere as the particle, and the s2 represents the surface area of the particle.



**Figure 1.** The sphere with the same particle size

The calculated particle shape coefficient curve is shown in Figure 2



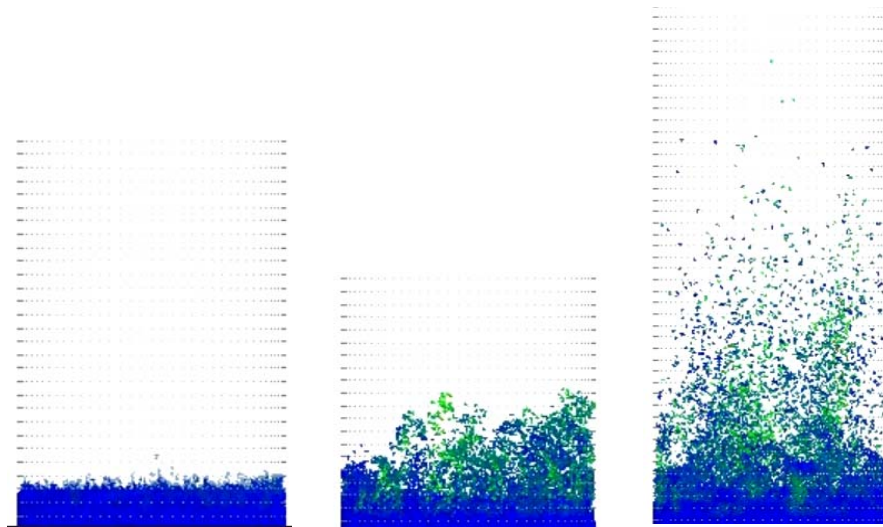
**Figure 2.** Shape factor of particles

### 3. CFD Simulation of the Particles Motion

Using pulverized coal particles as discrete phase, the inlet velocity of coal wind is 4m/s, the cold working condition temperature is 300K, the air density  $\rho=1.174\text{kg/m}^3$  dynamic viscosity  $\mu=1.84710^{-5}\text{Pas}$ , Reynolds number  $re=14560$ , and the outlet boundary condition is pressure outlet. Material property parameters as shown in the talbel 2. Velocity distribution of particles in Fluid bed are shown in figure 3.

**Table 2.** Material property parameters

| material                                    | parameter                    | value   |
|---|------------------------------|---------|
| Coal  | density kg/m3                | 1540    |
|   | Shear modulus pa             | 1.1e+09 |
|   | Poisson ratio                | 0.31    |
| Container material                          | Density kg/m3                | 1310    |
|   | Young's modulus/ pa          | 3e+9    |
|   | Poisson ratio                | 0.3     |
| Parameters between particles and containers | Static friction coefficient  | 0.5     |
|   | Dynamic friction coefficient | 0.6     |
|   | Recovery coefficient         | 0.05    |
| Parameters between particles                | Static friction coefficient  | 0.5     |
|   | Dynamic friction coefficient | 0.5     |
|   | Recovery coefficient         | 0.05    |



**Figure 3.** Velocity distribution of particles in Fluid bed

In the condition of wind speed 4m/s, the vibration fluidization of lignite in the opposite vibrating fluidized bed is simulated. Due to the fluidization action to overcome the gravity of the small particles, to form a floating fluidization state under the interaction of the particles, particles are periodically thrown upward and then back to the original position under the action of the airflow.

#### 4. Conclusion

Through the modeling and calculation of particles shape coefficients, the difference of shape factor between micron-level coal particles and millimeter-scale coal particles is not very large. However, coarse coal particles have large variance of the shape factor. The average shape factor of particles need to be obtained through large number of modeling and calculation, which provides a factual basis for calculating the traction force.

Through the CFD-DEM coupling simulation of the gas-solid two-phase flow in the fluid bed, in the vertical fluidized bed, the movement trajectory of the particles is mainly cyclical, the particles are affected by the fluid, and gradually move to the upper floor of the material layer to form a stratified vibration fluidization phenomenon. The displacement of the cast is higher, the other particles occupy the original position of the particles, and the particles can not return to the initial position and be raised to throw the next time.

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